

# XIA: Efficient Support for Evolvable Internetworking

Dongsu Han

Ashok Anand

Fahad Dogar

Boyan Li

**Hyeontaek Lim**

Michel Machado

Arvind Mukundan

Wenfei Wu

Aditya Akella

David G. Andersen

John W. Byers

Srinivasan Seshan

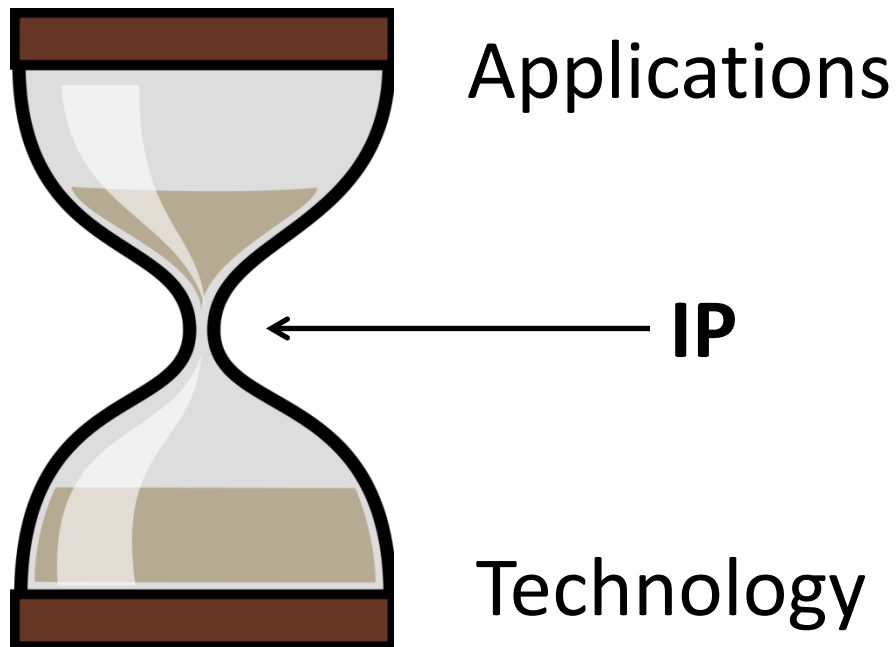
Peter Steenkiste

Carnegie Mellon

BOSTON  
UNIVERSITY



# IP: Narrow Waist of the Internet



Innovation both  
above and below IP

**But what about IP?**

# Proposed -Centric Networking

- Service: Serval (This NSDI!)
- Content: Named Data Networking
- Mobility: MobilityFirst
- Cloud: Nebula

Problem: Focusing on one communication type may hinder using other communication types, as occurred to IP

Can we support **heterogeneous** communication types on a **single** Internet architecture?

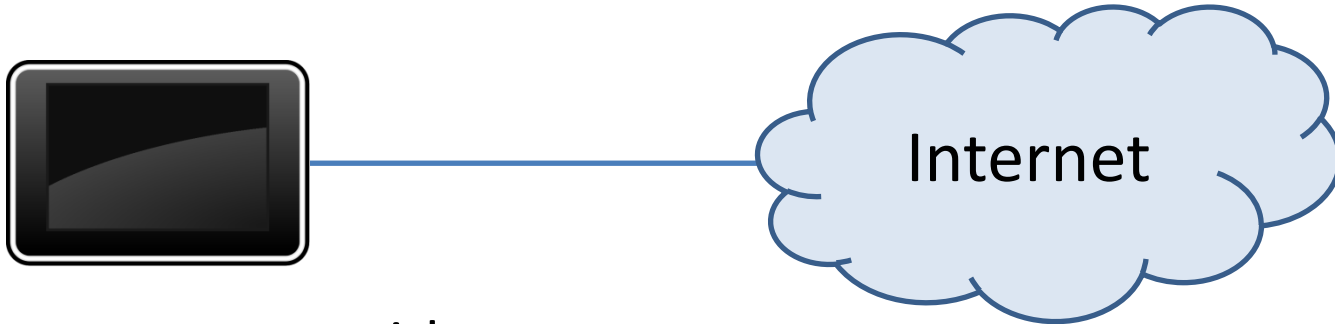
# Future -Centric Networking

- Service, content, mobility, and cloud did not receive much attention before as now
- Yet more networking styles may be useful in the future
  - E.g., DTN, wide-area multicast, ...?

Problem: Introducing additional communication types to the existing network can be very challenging

Can we support **future** communication types **without redesigning** the Internet architecture?

# Legacy Router May Prevent Innovation



“I got a computer with Awesome-Networking announced in NSDI 2022! Can I use it right now?”

“Ouch, we just replaced all of our routers built in 2012. Can you wait for another 10 years for new routers?”

Problem: Using a new communication type may require every legacy router in the network to be upgraded

Can we allow using a **new** communication type even when the network is **yet to natively support** it?

# XIA's Goals and Design Pillars



## “Principal types”

Support multiple communication types (heterogeneity)

Support future communication types (evolution)



## “Fallbacks”

Allow using new communication types at any point (incremental deployment)

# Principal Types

Define your own communication model

# Principals

## Current Internet

IP address

128.2.10.162

## XIA

Principal type	Type-specific identifier
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Host	0xF63C7A4...
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Hash of host's public key

Service	0x8A37037...
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Hash of service's public key

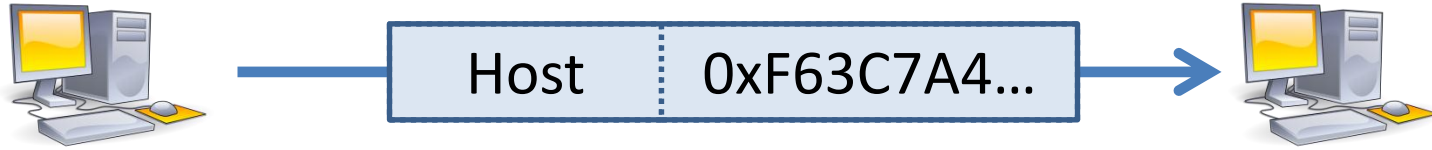
Content	0x47BF217...
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Hash of content

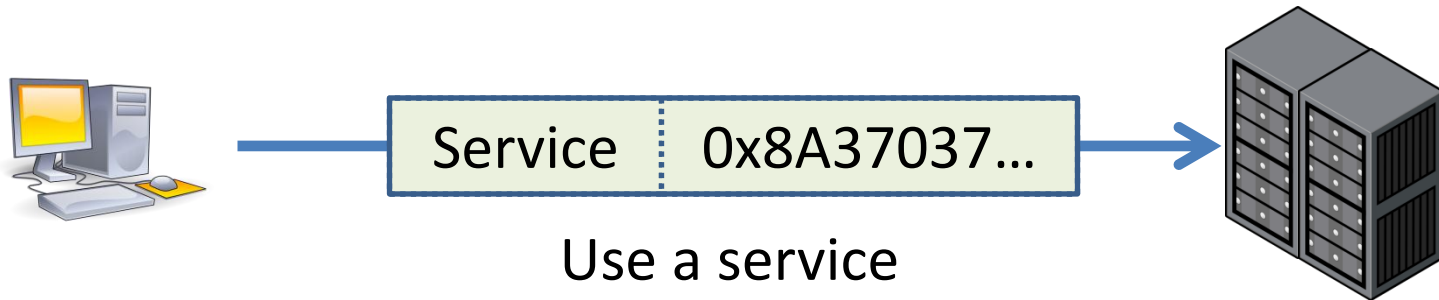
Future	...
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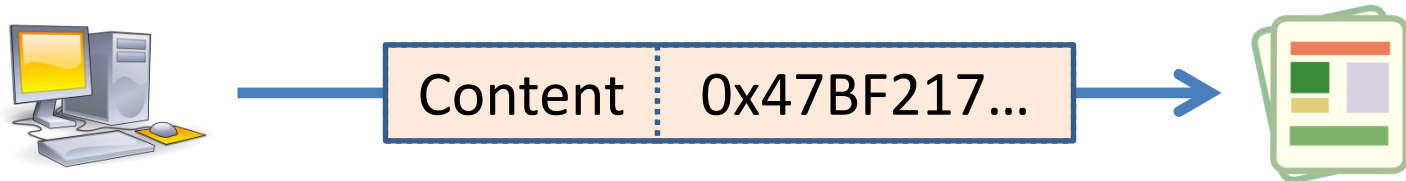
# Principal Type-Specific Semantics



Contact a host

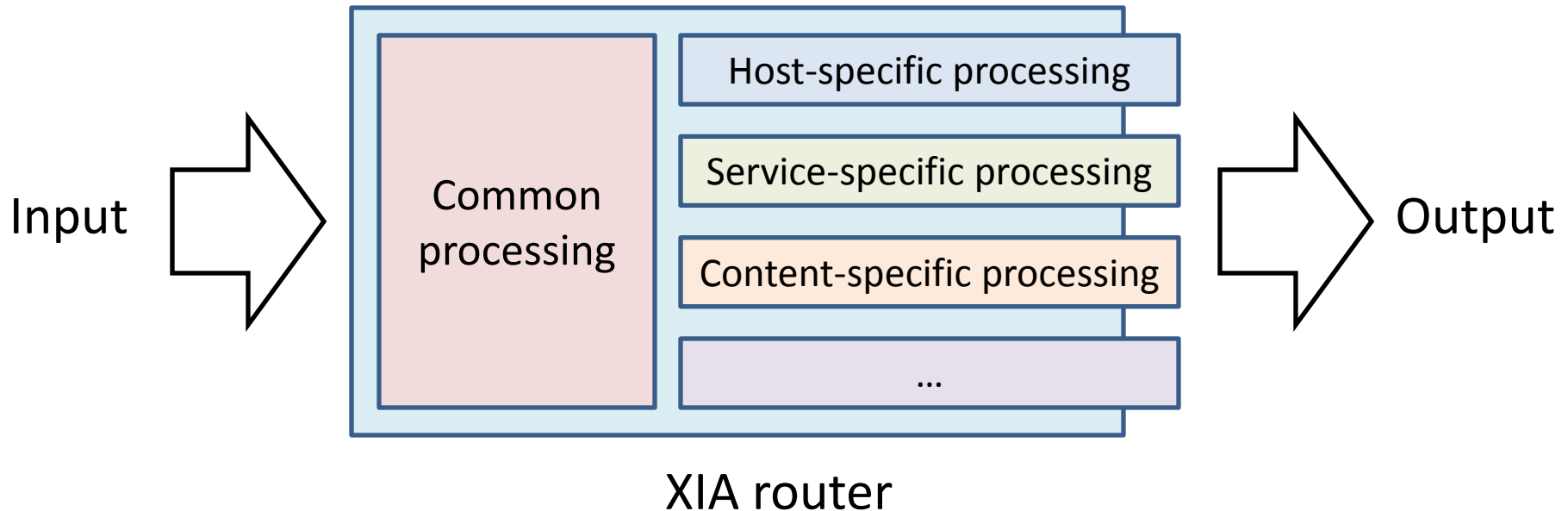


Use a service



Retrieve content

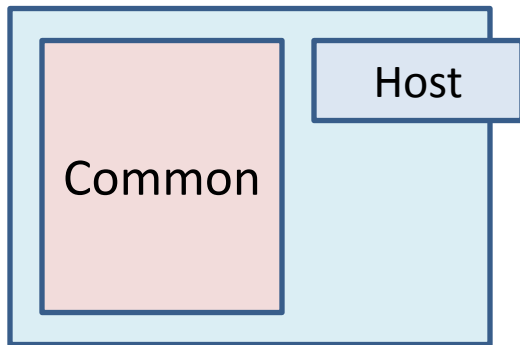
# Principal Type-Specific Processing



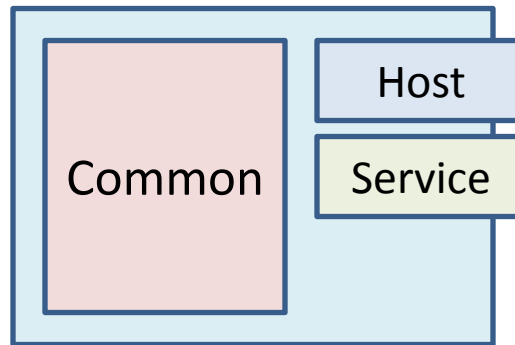
- Type-specific processing examples
  - Service: load balancing or service migration
  - Content: content caching

# Routers with Different Capabilities

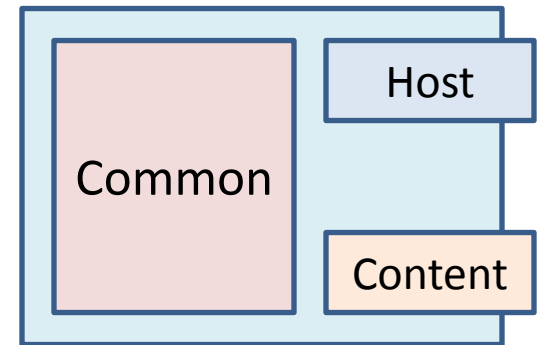
- Routers are **not** required to support every principal type
  - The only requirement: Host-based communication



Host-only router

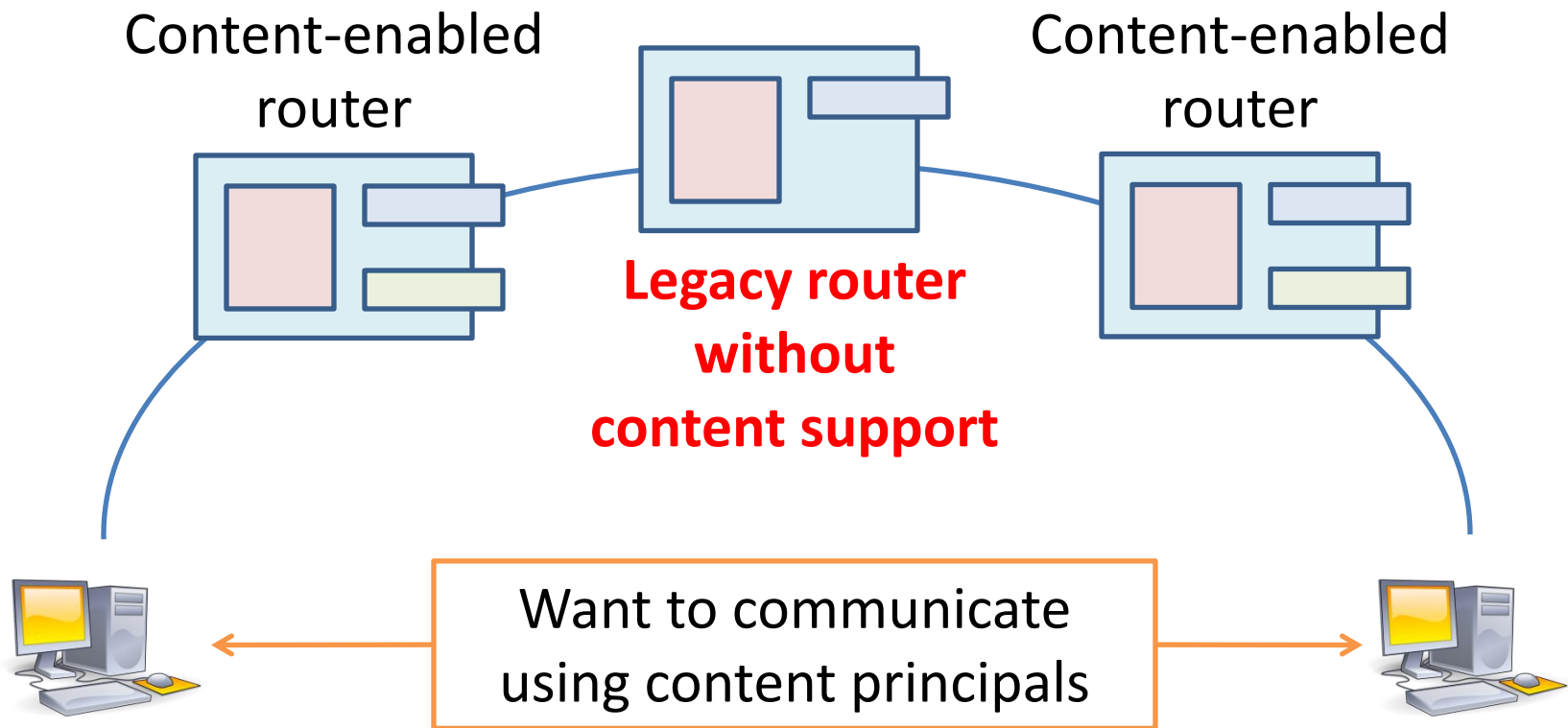


Service-enabled  
router



Content-enabled  
router

# Using Principal Types that are Not Understood by Legacy Routers?



# Fallbacks

Tomorrow's communication types... today!

# Fallbacks: Alternative Ways for Routers to Fulfill Intent of Packet

Intent: Retrieve Content

**Fallback:** Contact Host ,  
who understands Content request

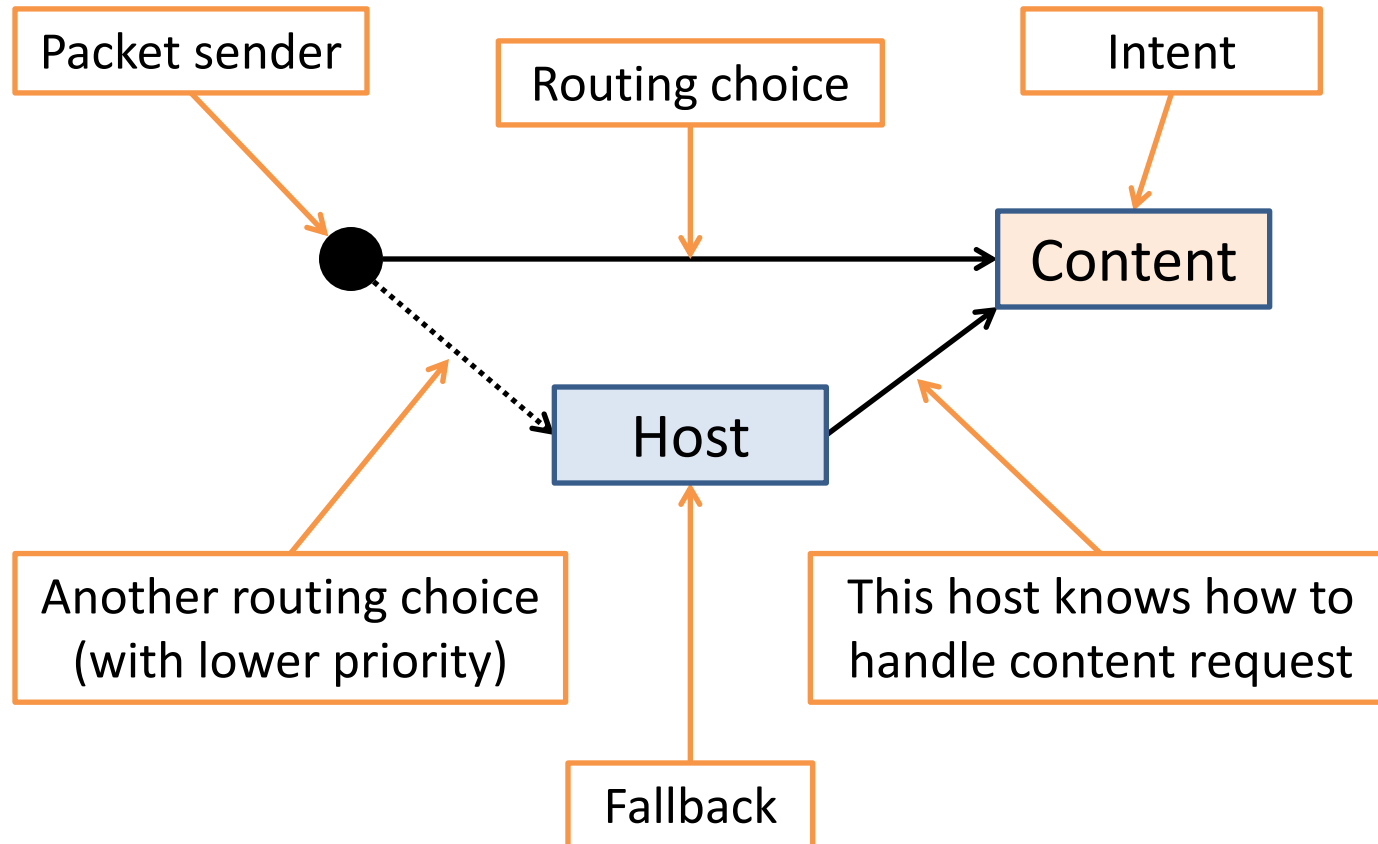
What the network does:

- With content-enabled routers, use Content for routing
- Otherwise, use Host for routing (always succeeds)

# DAG-Based Address

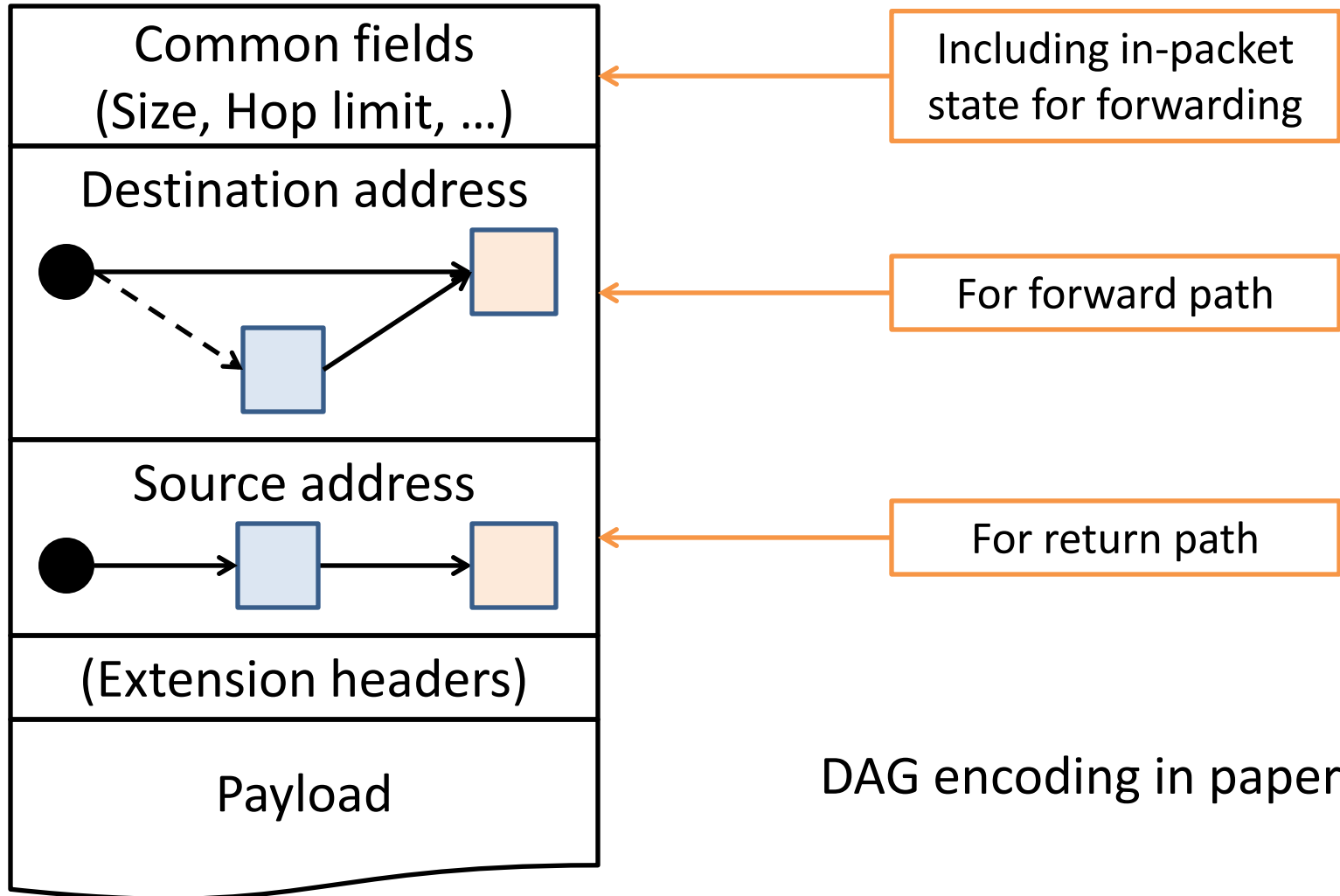
Your address is more than a number

# DAG (Direct Acyclic Graph)-Based Addressing Enables Fallbacks





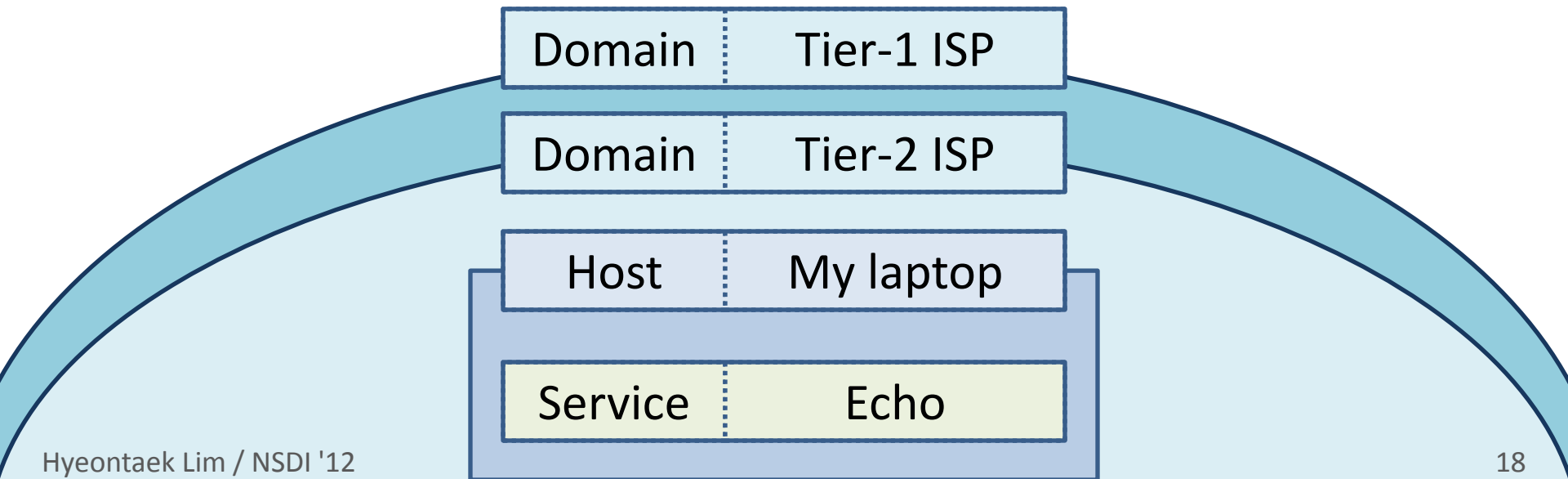
# DAG Addresses in Packet Header



# Scoping Using DAG

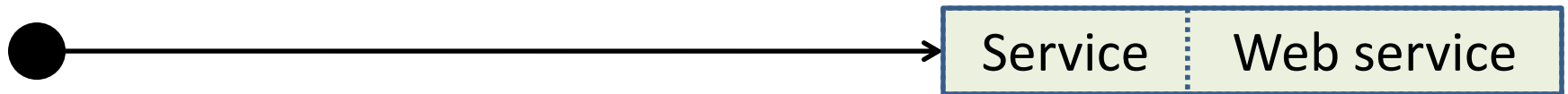


More specific intent & Better scalability

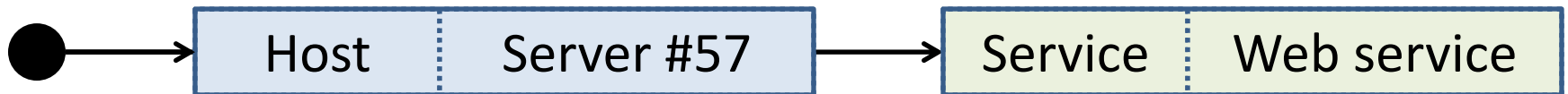


# Service Binding with DAG

Initial contact to a service

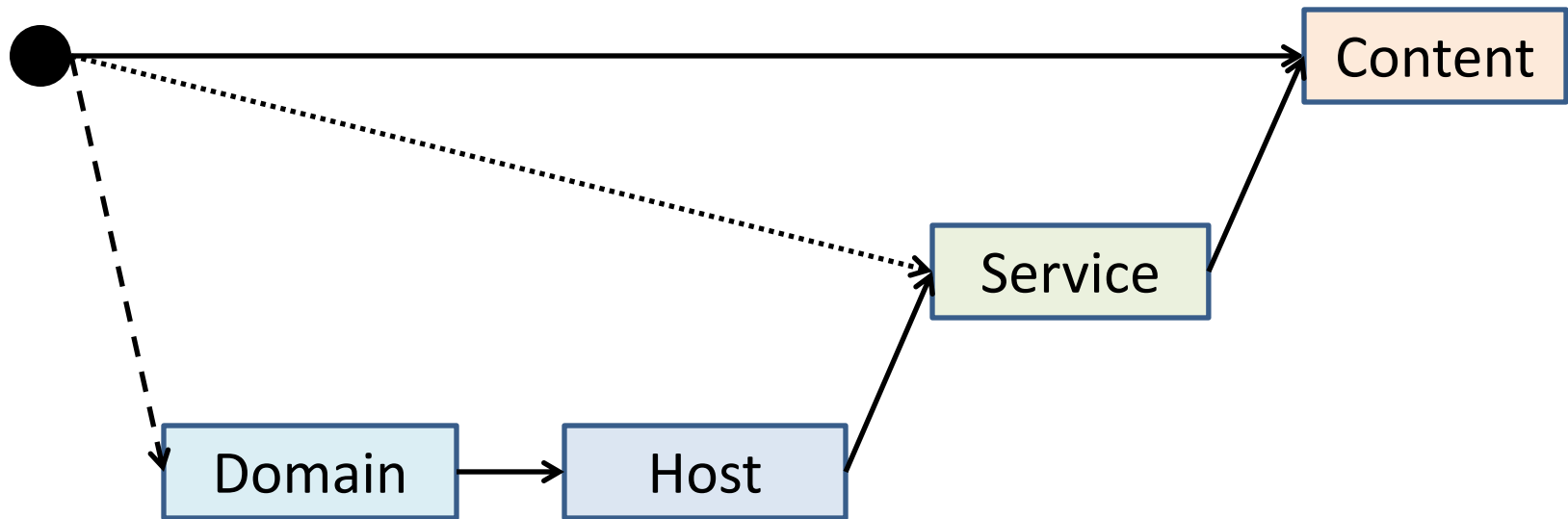


When a particular host should serve subsequent service requests



“Late binding”

# DAG Allows Nested Fallbacks

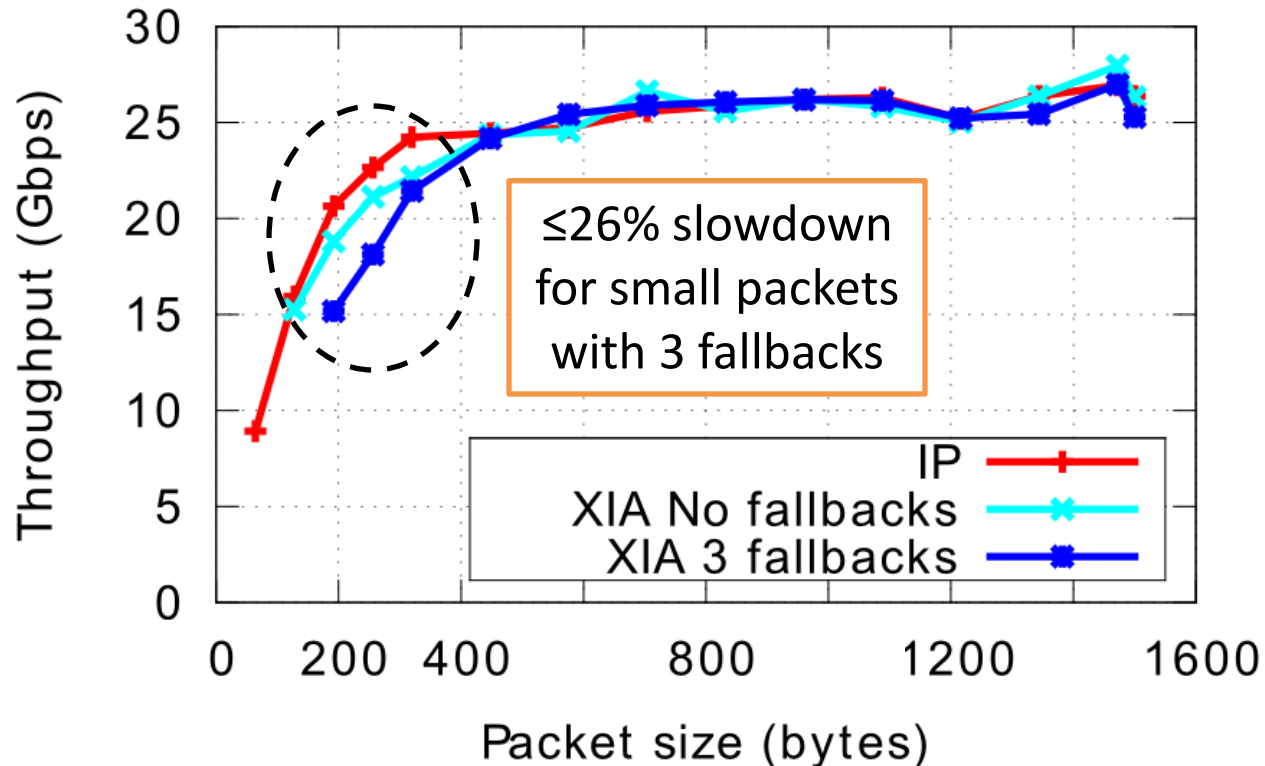


Strong support for evolvable internetworking

# Can We Forward DAGs Rapidly?

Expressive  $\neq$  Expensive

# XIA Software Router's High Forwarding Throughput

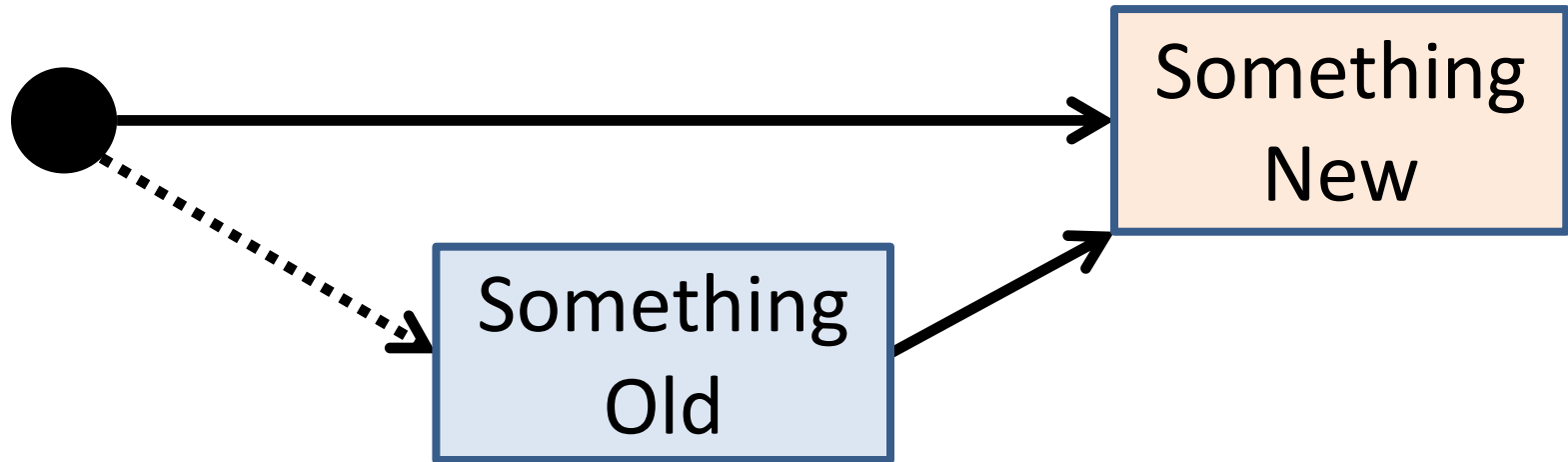


Click-based implementation on commodity hardware  
351 K table entries based on a Route Views snapshot

# XIA: eXpressive Internet Architecture

- Support for evolvable internetworking
  - Heterogeneous communication types
  - Future communication types
  - Incremental deployment of new communication types
- Principal types & fallbacks
- DAG-based addressing

# XIA: Enabling Evolution by eXpression



- Prototype: [github.com/XIA-Project/xia-core](https://github.com/XIA-Project/xia-core)
  - Router, socket, content cache, etc.
  - Supports LAN, XIA-over-IP, GENI